

CLAIMS

Having thus described our invention in detail, what we claim as new and desire to secure by the Letters Patent is:

- 1 1. A method of producing a thin, high-quality, substantially relaxed SiGe-on-insulator
2 substrate material comprising the steps of:
3
4 (a) forming a SiGe or pure Ge layer on a surface of a first single crystal Si layer, said
5 first single crystal Si layer is present atop a barrier layer that is resistant to Ge diffusion;
6 and
7
8 (b) heating said layers at a temperature which permits interdiffusion of Ge throughout
9 said first single crystal Si layer and said SiGe or pure Ge layer thereby forming a
10 substantially relaxed, single crystal SiGe layer atop said barrier layer.
- 1 2. The method of Claim 1 wherein said first single crystal Si layer and said barrier layer
2 are components of a silicon-on-insulator (SOI) substrate.
- 1 3. The method of Claim 1 wherein said first single crystal Si layer and said barrier layer
2 are components of a non-SOI substrate.
- 1 4. The method of Claim 3 wherein said first single crystal Si layer has a thickness of
2 from about 1 to about 2000 nm.
- 1 5. The method of Claim 1 wherein said barrier layer is a patterned barrier layer.
- 1 6. The method of Claim 1 wherein said barrier layer is an unpatterned barrier layer.
- 1 7. The method of Claim 1 wherein said barrier layer comprises crystalline or non-
2 crystalline oxides, or crystalline or non-crystalline nitrides.

- 1 8. The method of Claim 1 wherein said barrier layer is a buried oxide region that is
2 patterned or unpatterned.
- 1 9. The method of Claim 1 wherein said barrier layer has a thickness of from about 1 to
2 about 1000 nm.
- 1 10. The method of Claim 1 wherein a SiGe layer comprising up to 99.99 atomic percent
2 Ge is employed in step (a).
- 1 11. The method of Claim 10 wherein said SiGe layer comprises from about 10 to about
2 35 atomic percent Ge.
- 1 12. The method of Claim 1 wherein said SiGe or pure Ge layer is formed by an epitaxial
2 growth process selected from the group consisting of low-pressure chemical vapor
3 deposition, atmospheric pressure chemical vapor deposition, ultra-high vacuum
4 chemical vapor deposition, molecular beam epitaxy, and plasma-enhanced chemical
5 vapor deposition.
- 1 13. The method of Claim 1 wherein a pure Ge layer is employed in step (a).
- 1 14. The method of Claim 1 further comprising forming a Si cap layer atop said SiGe or
2 pure Ge layer prior to performing step (b).
- 1 15. The method of Claim 14 wherein said Si cap layer comprises epi-Si, a-Si, single or
2 polycrystalline Si or any combination and multilayer thereof.
- 1 16. The method of Claim 15 wherein said Si cap layer comprises epi-Si.

- 1 17. The method of Claim 14 wherein said Si cap layer has a thickness of from about 1 to
2 about 100 nm.
- 1 18. The method of Claim 1 wherein a surface oxide layer forms during said heating
2 step.
- 1 19. The method of Claim 18 wherein said surface oxide layer has a thickness of from
2 about 10 to about 1000 nm.
- 1 20. The method of Claim 18 further comprising removing said surface oxide layer
2 utilizing a wet chemical etch process.
- 1 21. The method of Claim 1 wherein steps (a)-(b) are repeated any number of times.
- 1 22. The method of Claim 1 wherein said heating step is carried out in an oxidizing
2 ambient which comprises at least one oxygen-containing gas.
- 1 23. The method of Claim 22 wherein said at least one oxygen-containing gas comprises
2 O₂, NO, N₂O, ozone, air or mixtures thereof.
- 1 24. The method of Claim 22 further comprising an inert gas, said inert gas being
2 employed to dilute said at least one oxygen-containing gas.
- 1 25. The method of Claim 1 wherein said heating step is performed at a temperature of
2 from about 900° to about 1350°C.
- 1 26. The method of Claim 25 wherein said heating step is performed at a temperature of
2 from about 1200° to about 1335°C.

- 1 27. The method of Claim 1 wherein said substantially relaxed SiGe layer has a thickness
2 of about 2000 nm or less.
- 1 28. The method of Claim 27 wherein said substantially relaxed SiGe layer has a
2 thickness of from about 10 to about 100 nm.
- 1 29. The method of Claim 1 wherein said substantially relaxed SiGe layer has a defect
2 density of less than about 10^8 defects/cm².
- 1 30. The method of Claim 1 wherein said substantially relaxed SiGe layer has a
2 measured lattice relaxation of from about 1 to about 100 %.
- 1 31. The method of Claim 30 wherein said substantially relaxed SiGe layer has a
2 measured lattice relaxation of from about 50 to about 80 %.
- 1 32. The method of Claim 1 further comprising growing an additional SiGe layer atop
2 said substantially relaxed SiGe layer.
- 1 33. The method of Claim 32 further comprising forming a strained Si layer atop said
2 additional SiGe layer.
- 1 34. The method of Claim 1 further comprising forming a strained Si layer atop said
2 substantially relaxed SiGe layer.
- 1 35. A substrate material comprising:
2
3 a Si-containing substrate;
4
5 an insulating region that is resistant to Ge diffusion present atop said Si-containing
6 substrate; and

7

8 a substantially relaxed SiGe layer present atop said insulating region, wherein said
9 substantially relaxed SiGe layer has a thickness of about 2000 nm or less.

1 36. The substrate material of Claim 35 wherein said insulating region is patterned.

1 37. The substrate material of Claim 35 wherein said insulating region is unpatterned.

1 38. The substrate material of Claim 35 wherein said insulating region comprises
2 crystalline or non-crystalline oxides, or crystalline or non-crystalline nitrides.

1 39. The substrate material of Claim 35 wherein said insulating region is a buried oxide
2 region that is patterned or unpatterned.

1 40. The substrate material of Claim 35 wherein said insulating region has a thickness of
2 from about 1 to about 1000 nm.

1 41. The substrate material of Claim 35 wherein said substantially relaxed SiGe layer has
2 a thickness of from about 10 to about 100 nm.

1 42. The substrate material of Claim 36 wherein said substantially relaxed SiGe layer has
2 a measured lattice relaxation of from about 1 to about 100 %.

1 43. The substrate material of Claim 42 wherein said substantially relaxed SiGe layer has
2 a measured lattice relaxation of from about 50 to about 80 %.

1 44. A heterostructure comprising:
2

3 a Si-containing substrate;
4

5 an insulating region that is resistant to Ge diffusion present atop the Si-containing
6 substrate;
7
8 a substantially relaxed SiGe layer present atop the insulating region, wherein the
9 substantially relaxed SiGe layer has a thickness of about 2000 nm or less;
10
11 and a strained Si layer formed atop the substantially relaxed SiGe layer.

1 45. The heterostructure of Claim 44 wherein said insulating region is patterned.

1 46. The heterostructure of Claim 44 wherein said insulating region is unpatterned.

1 47. The heterostructure of Claim 44 wherein said insulating region comprises crystalline
2 or non-crystalline oxides, or crystalline or non-crystalline nitride.

1 48. The heterostructure of Claim 44 wherein said insulating region barrier layer is a
2 buried oxide region that is patterned or unpatterned.

1 49. The heterostructure of Claim 44 wherein said insulating region has a thickness of
2 from about 20 to about 200 nm.

1 50. The heterostructure of Claim 44 wherein said substantially relaxed SiGe layer has a
2 thickness of from about 10 to about 100 nm.

1 51. The heterostructure of Claim 44 wherein said substantially relaxed SiGe layer has a
2 measured lattice relaxation of from about 1 to about 100 %.

1 52. The heterostructure of Claim 51 wherein said substantially relaxed SiGe layer has a
2 measured lattice relaxation of from about 50 to about 80 %.

- 1 53. The heterostructure of Claim 44 wherein said strained Si layer has a thickness of
2 from about 1 to about 100 nm.
- 1 54. The heterostructure of Claim 44 wherein said strained Si layer comprises an epi-Si
2 layer.
- 1 55. The heterostructure of Claim 44 wherein alternating layers of relaxed SiGe and
2 strained Si are formed atop said strained Si layer.
- 1 56. The heterostructure of Claim 44 wherein said strained Si layer is replaced with a
2 lattice mismatched compound selected from the group consisting of GaAs and GaP.

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